MODIS Science Team Meeting, June 6-10, 2016, Silver Spring, MD

Daily Monitoring of Crop Condition and Water Use using MODIS, Landsat and Geostationary Data

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Objective: **map crop progress, water use, and drought impacts at 30-m spatial resolution by fusing MODIS, Landsat and geostationary satellites**

TOOLS

STARFM	Multi-sensor data fusion
DMS	Thermal image sharpening
ALEXI	Multi-scale ET modeling

ASSETS

		SW/TIR
GEO	Hourly	5km/5km
MODIS	Daily	250m/1km
Landsat	16 day	30m/100m
Lsat-like		~20-60m/ --

APPLICATIONS
(daily/30 m)


Crop phenology metrics


Crop water use (Evapotranspiration)


Crop stress (drought early warning)

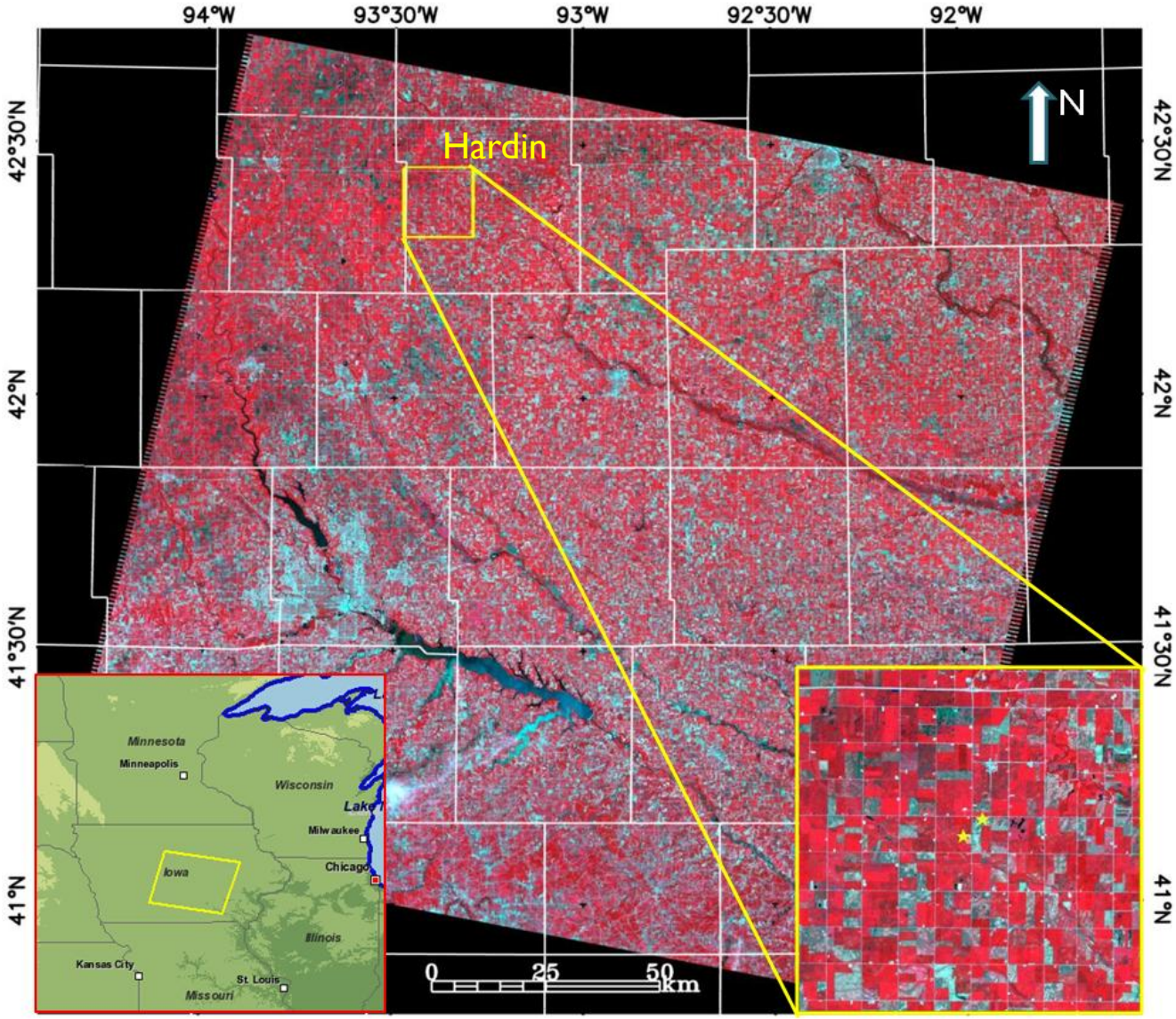

Impact on yield

Progress and Plan

- Year 1: Tools Development and System Integration
  - STARFM data fusion system automation
  - Evapotranspiration (ET) model integration and system automation
  - Crop phenology programs evaluation
- Year 2: System Testing and Results Validation
  - a rain-fed agricultural area in central Iowa
  - a vineyard field experiment (GRAPEX) site in Lodi, CA
  - a managed pine plantation in NC
  - a tile-drained agricultural landscape in SD
  - an irrigated agricultural system in the Central Sands or WI
  - the Walnut Gulch watershed, AZ
  - several ARS Long-Term Agricultural Research (LTAR) sites including Mead, NE, the OPE3 and Choptank watershed sites in the lower Chesapeake Bay
- Year 3: Application Extension and Yield Impact

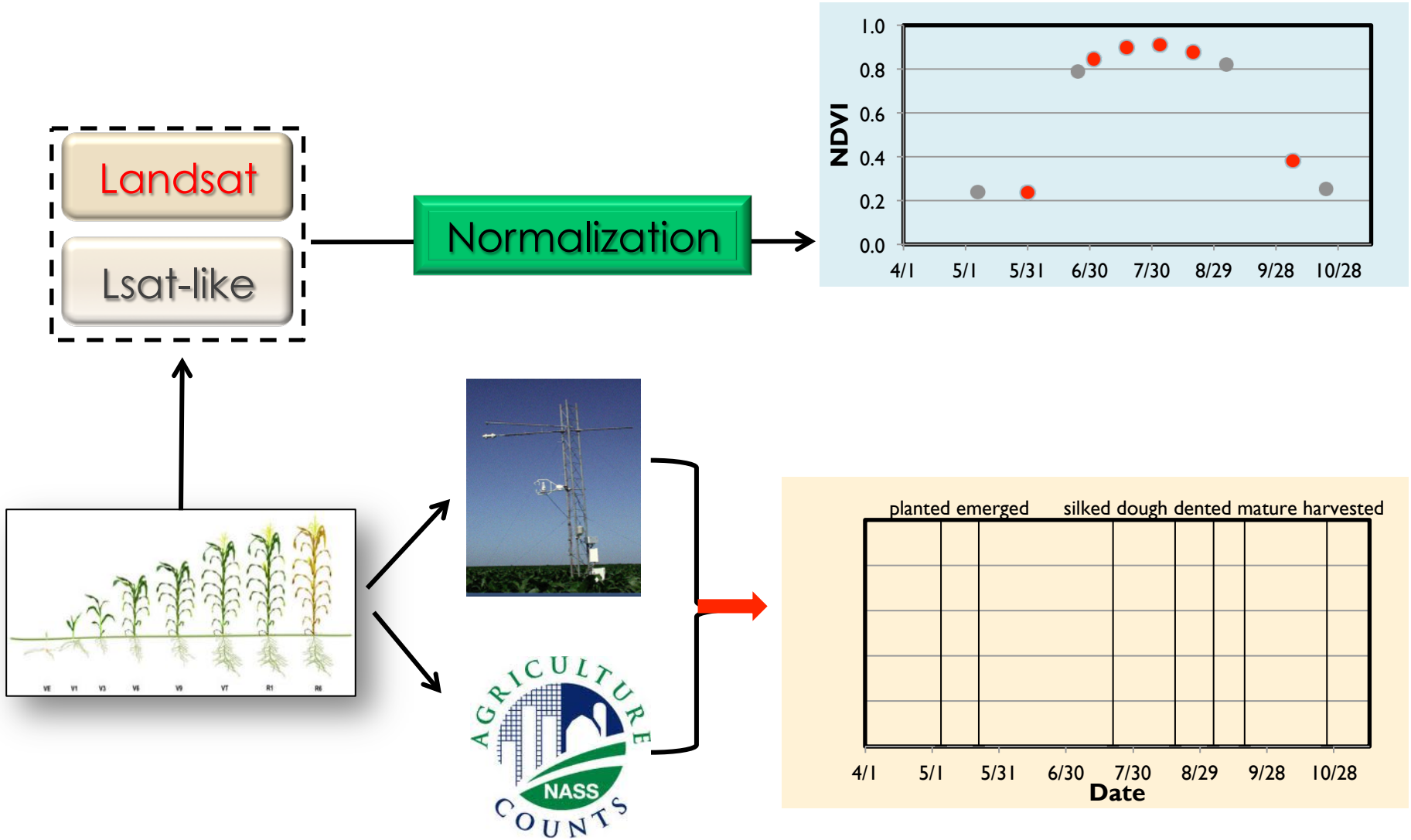
Crop Condition and Water Use Monitoring

Case 1: central Iowa (~20 counties)



Fourteen years (2001-2014) of Landsat TM, ETM+ and OLI (p26r31) and MODIS (h10v04 and h11v04) were fused to generate daily Landsat-MODIS surface reflectance at 30m resolution using STARFM

Mapping Crop Growth Stages using MODIS & Landsat



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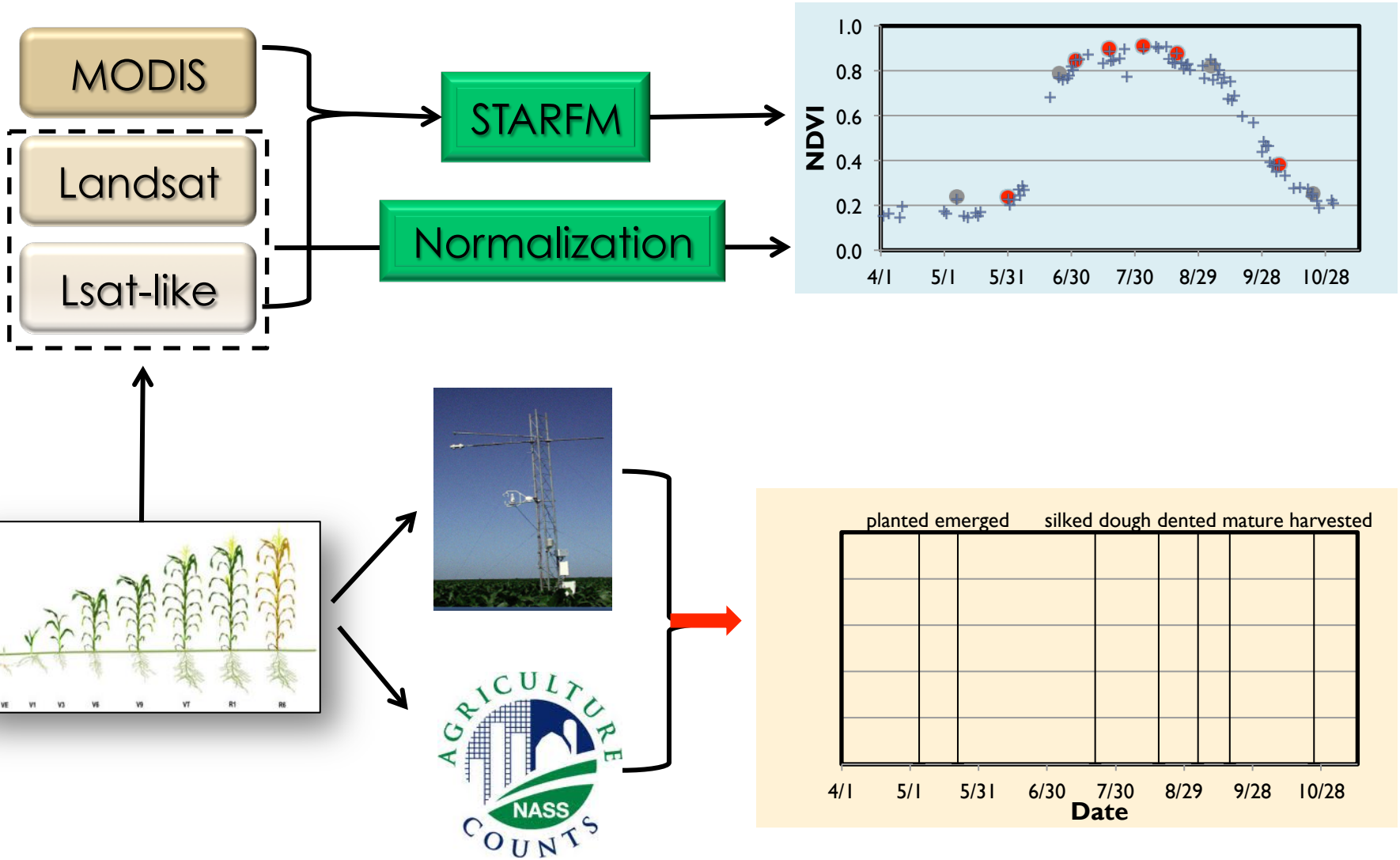

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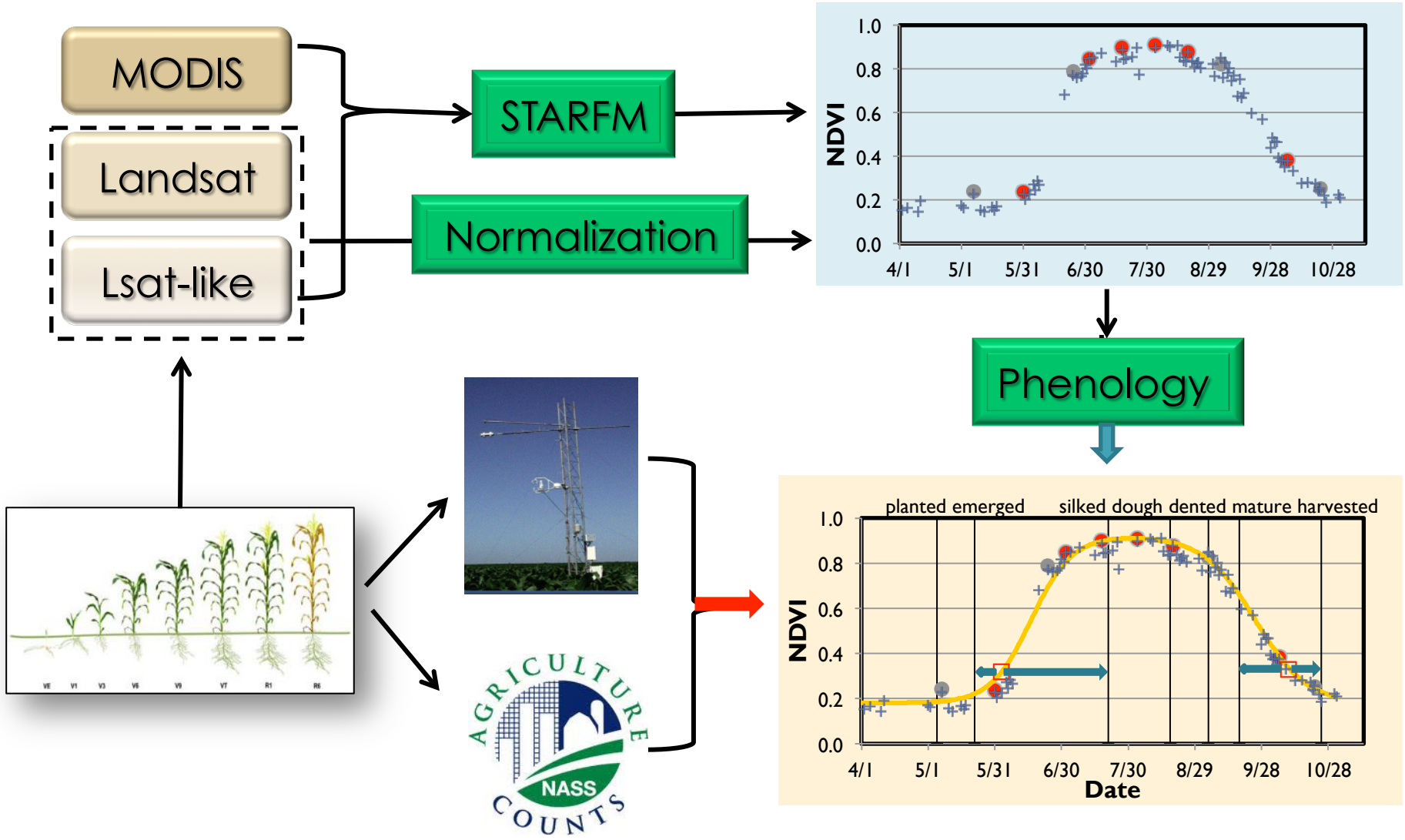
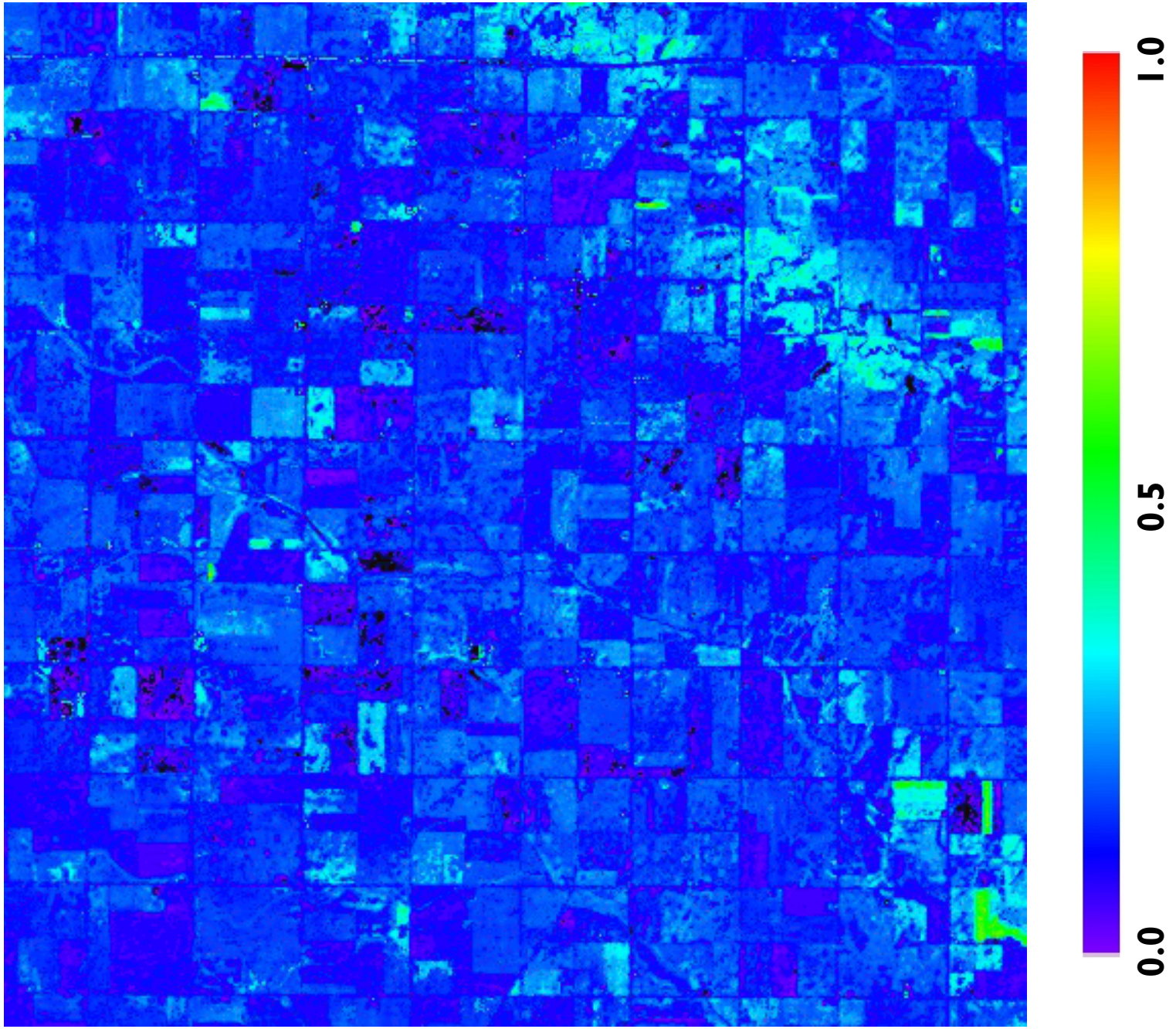
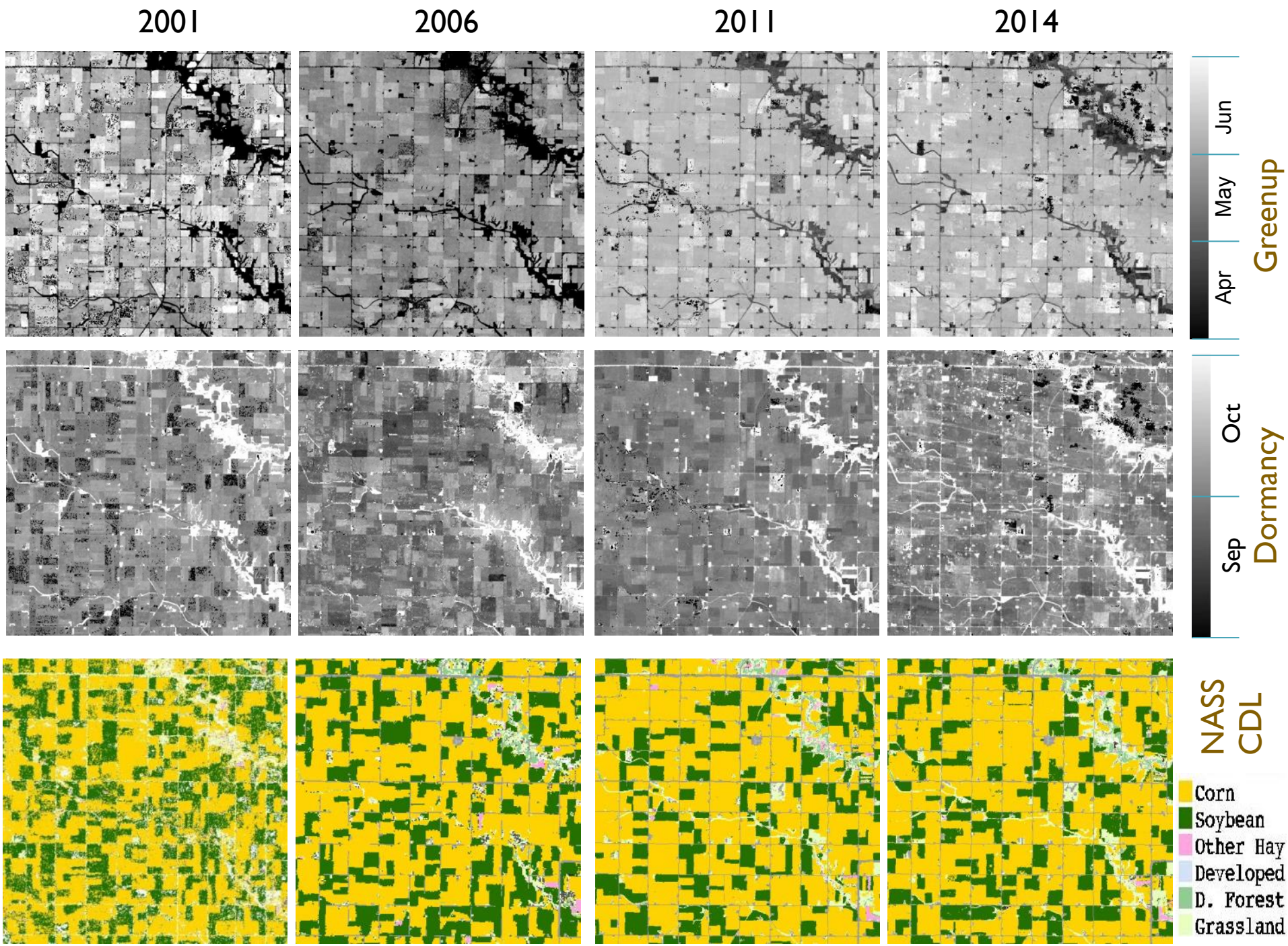


Crop Condition and Water Use Monitoring

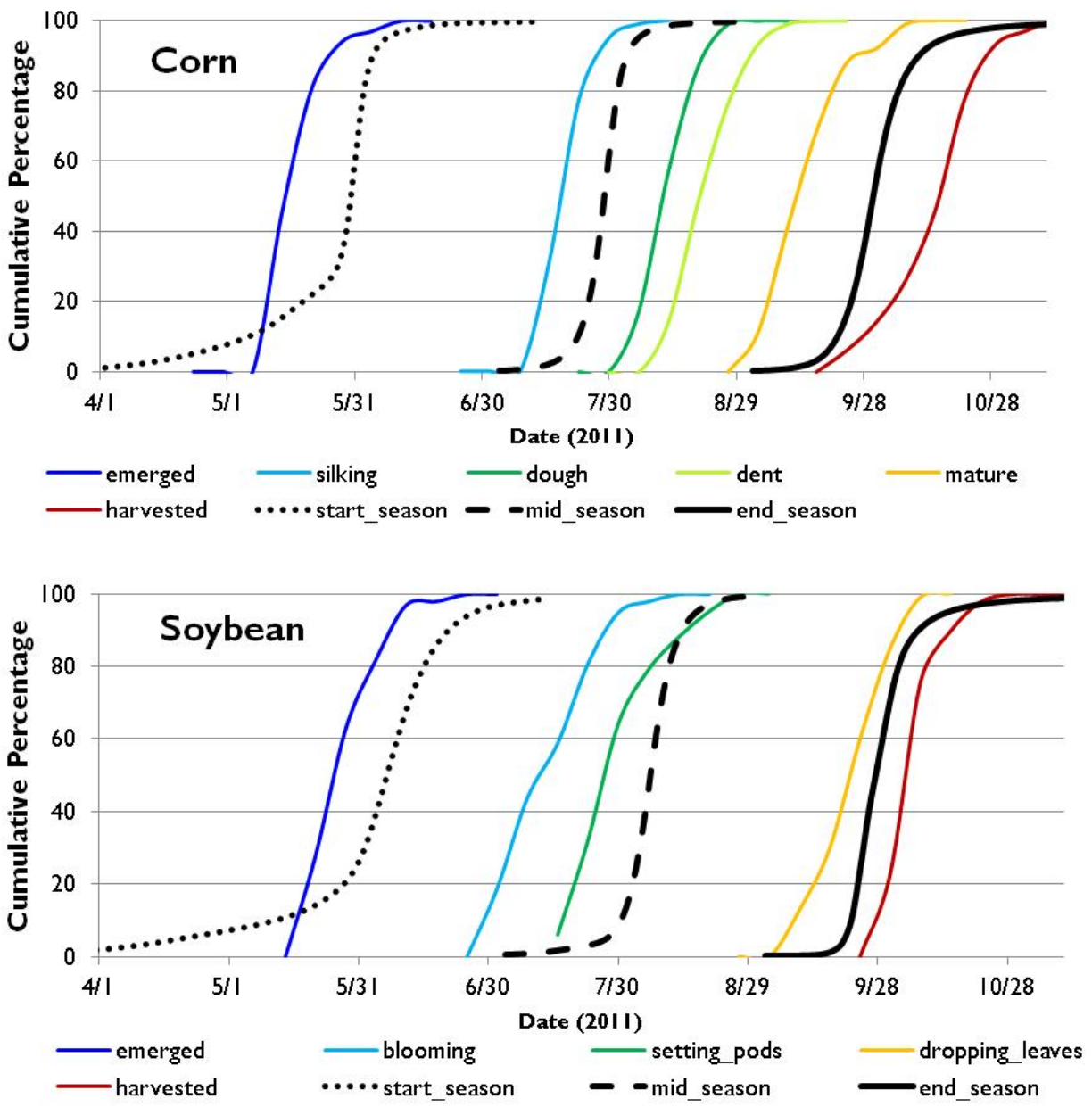


Smoothed (double logistic function) Daily NDVI, Apr. 1 – Nov. 1, 2011


2001
2006
2011
2014
Jun
May
Apr
Greenup
Oct
Sep
Dormancy
NASS CDL
Corn
Soybean
Other Hay
Developed
D. Forest
Grassland

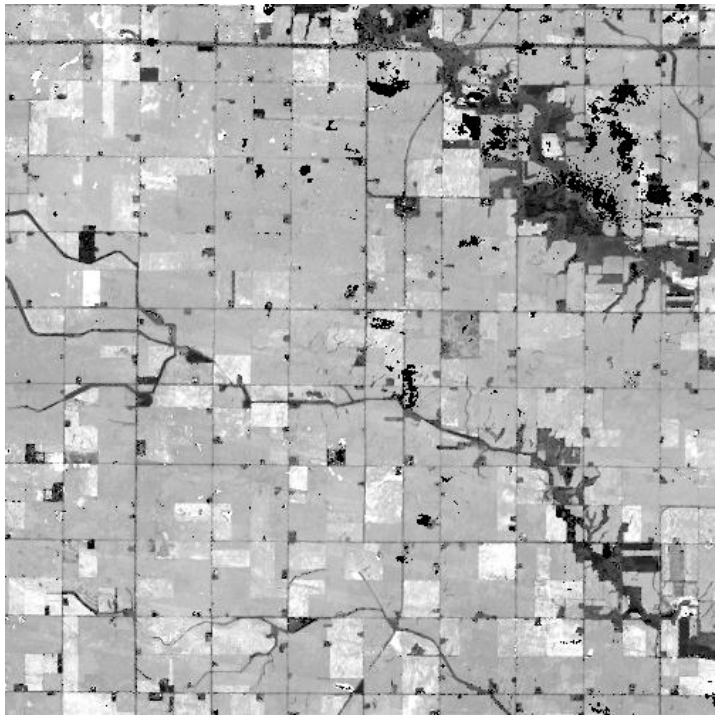
Phenology (RS) vs. Crop Growth Stages (NASS)

crop growth stages from central Iowa (online 2011CP reports)

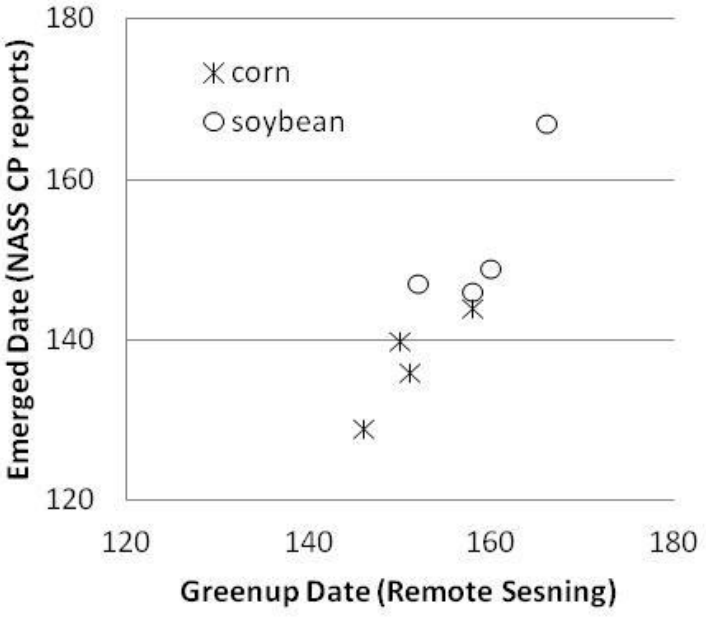


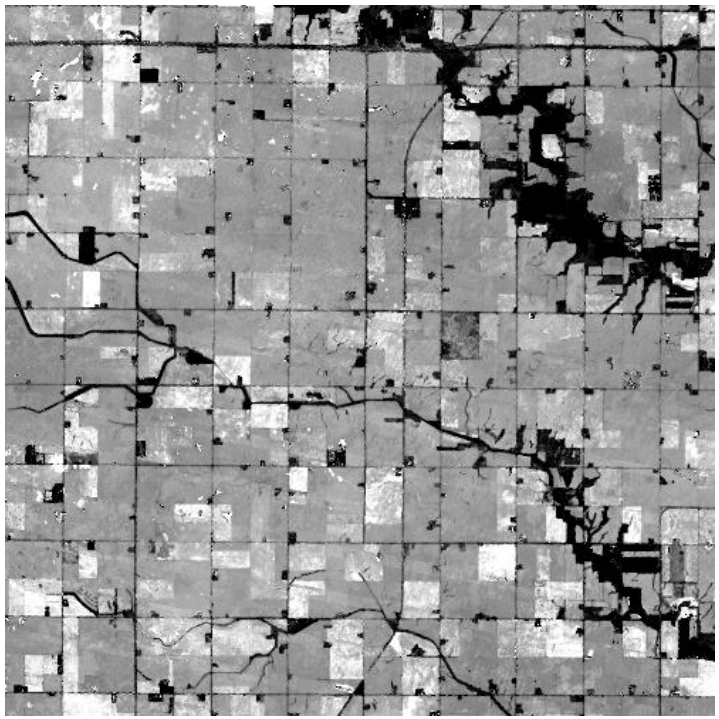
Remote Sensing Phenology to Crop Growth Stages

Greenup date



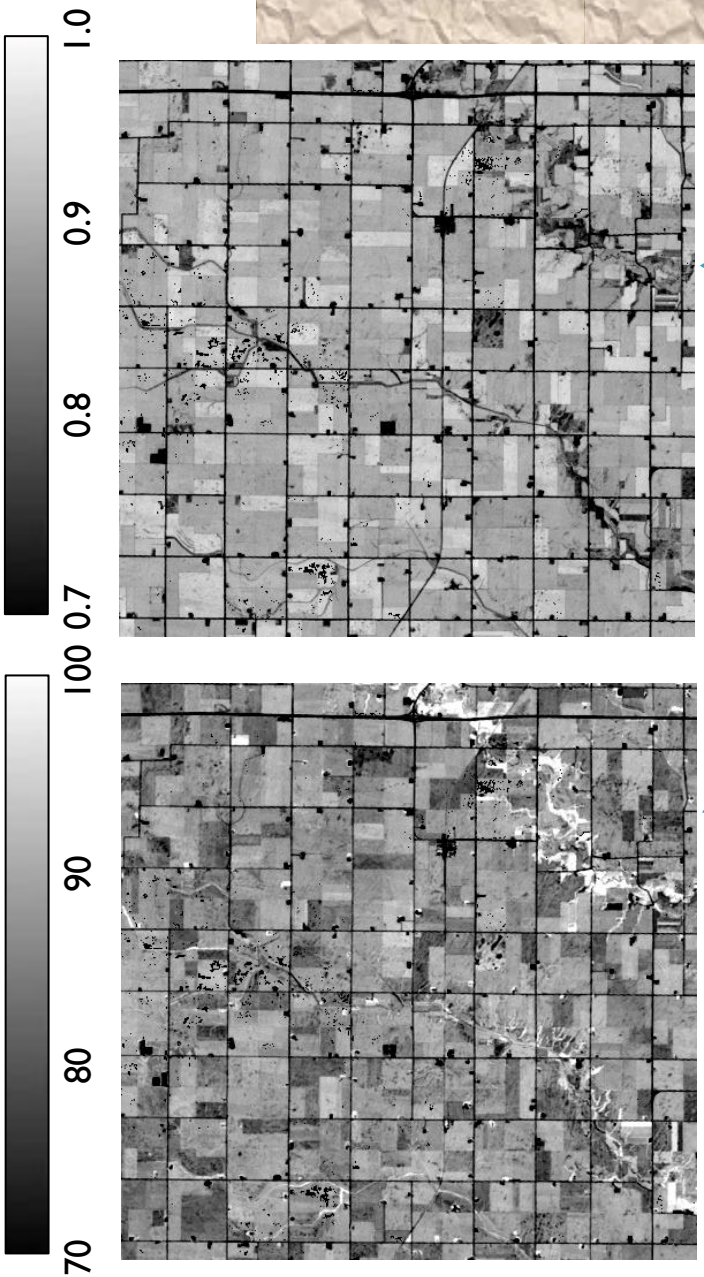
Relationship from previous years



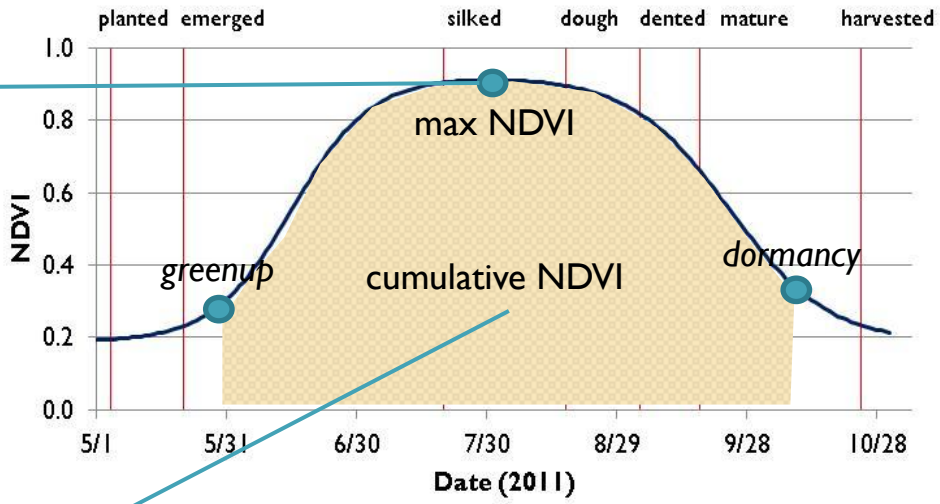


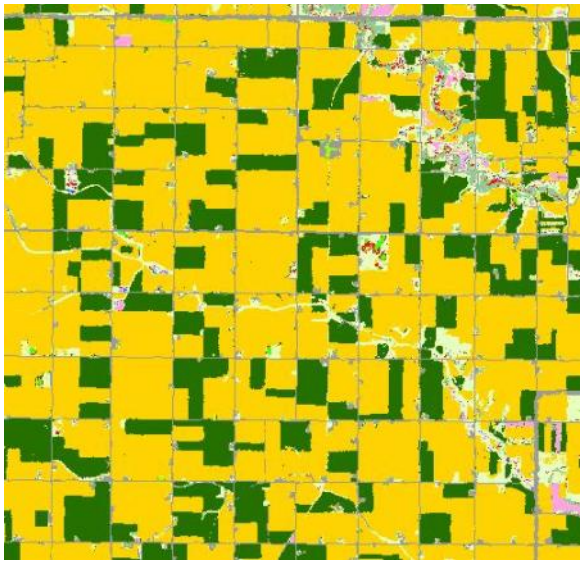
Backcast Emerged Date (2014)

$$Yield = \sum \left[PAR_i \times fPAR_i \times LUE_i(\varepsilon_{\max}, T, ET) \right] * HI$$



$$fPAR_i = f(NDVI_i)$$

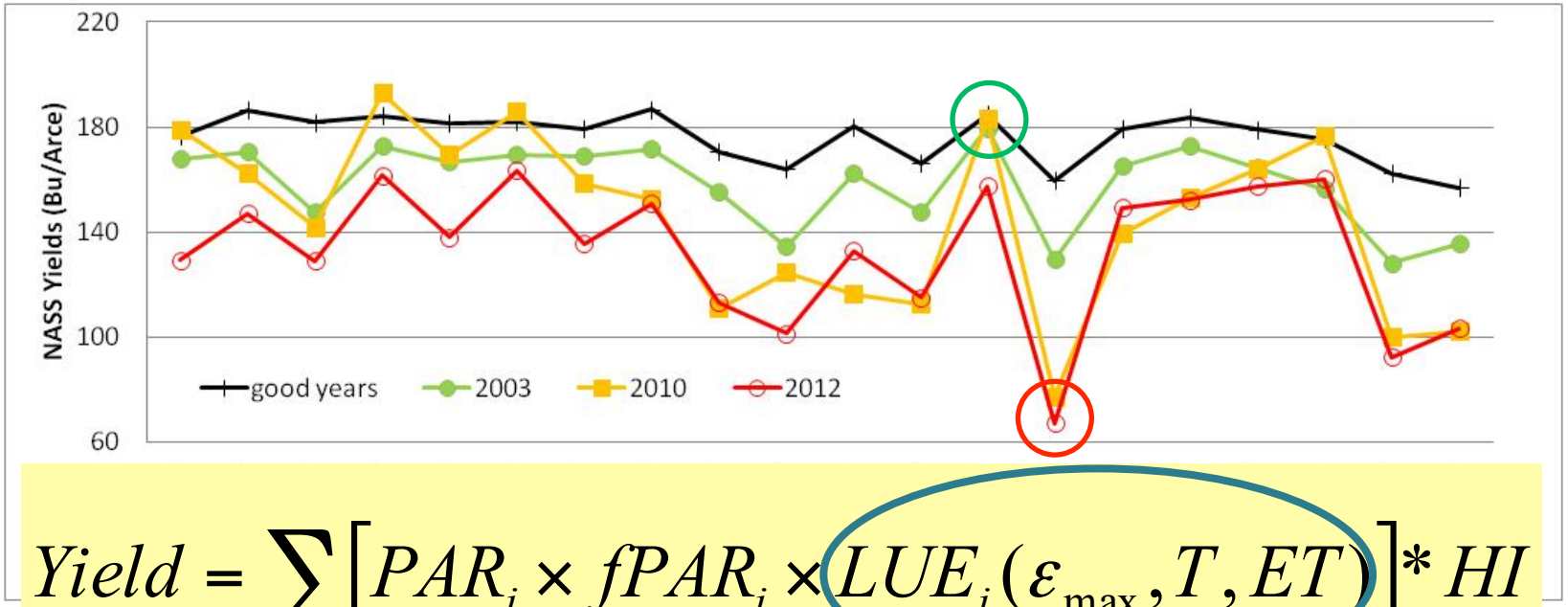




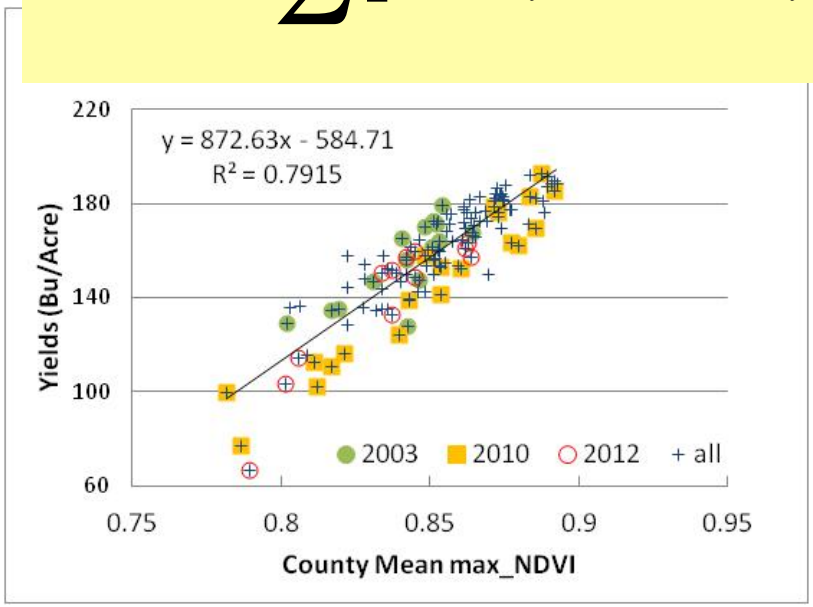
NASS CDL (2011)

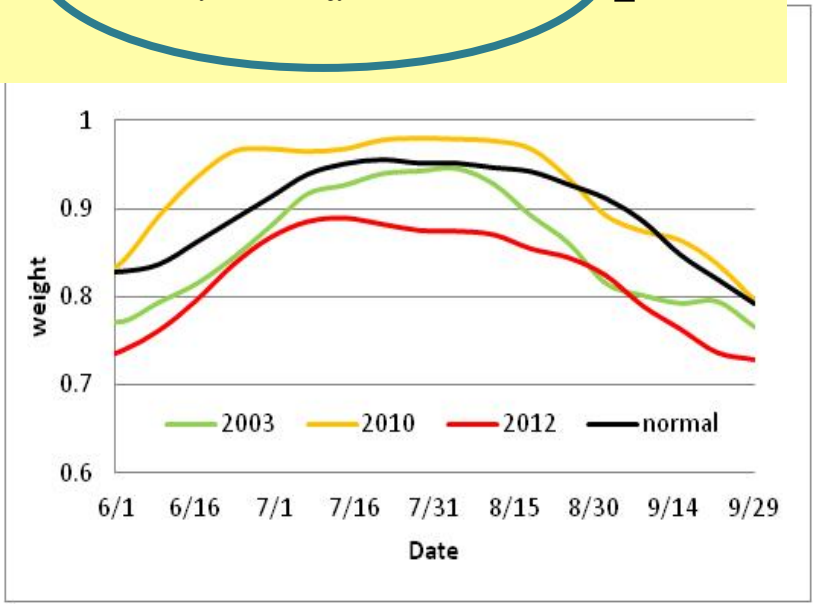
Corn
Soybean
Other Hay
Developed
D. Forest
Grassland

Corn yields and NDVI metrics (county level)

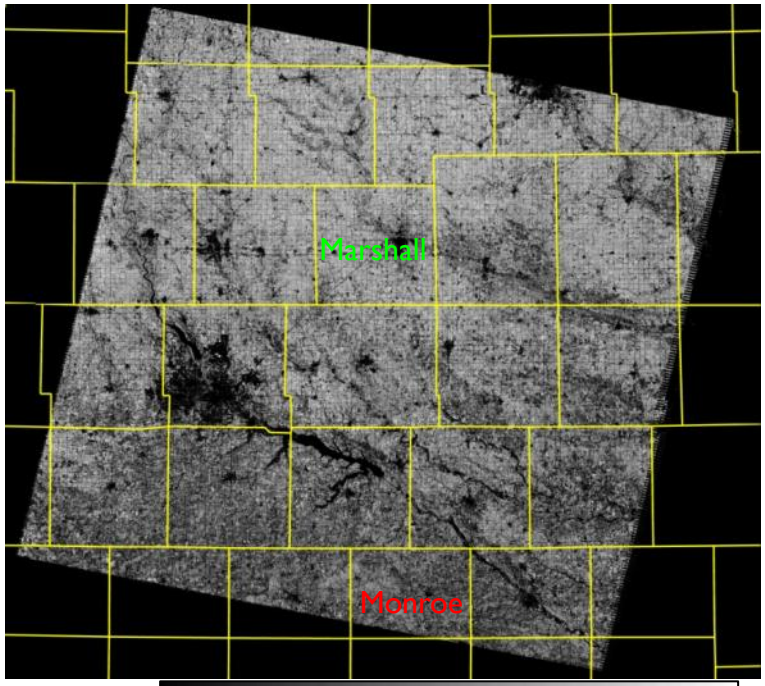


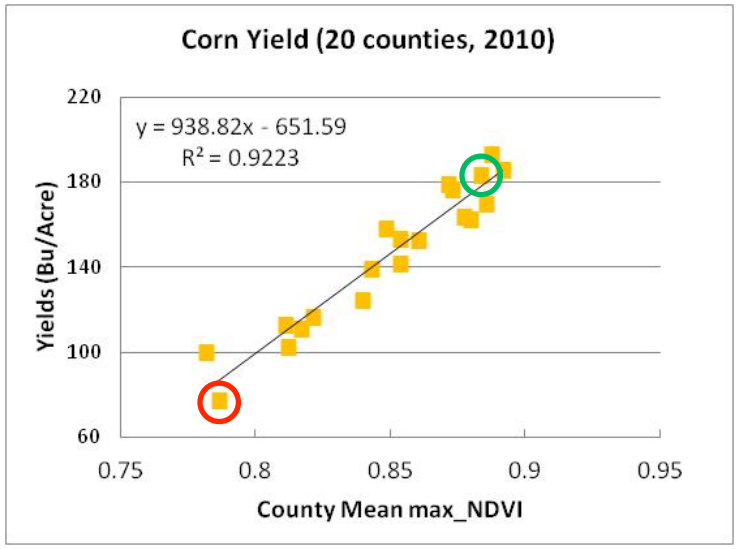
$$Yield = \sum \left[PAR_i \times fPAR_i \times LUE_i(\varepsilon_{\max}, T, ET) \right] * HI$$

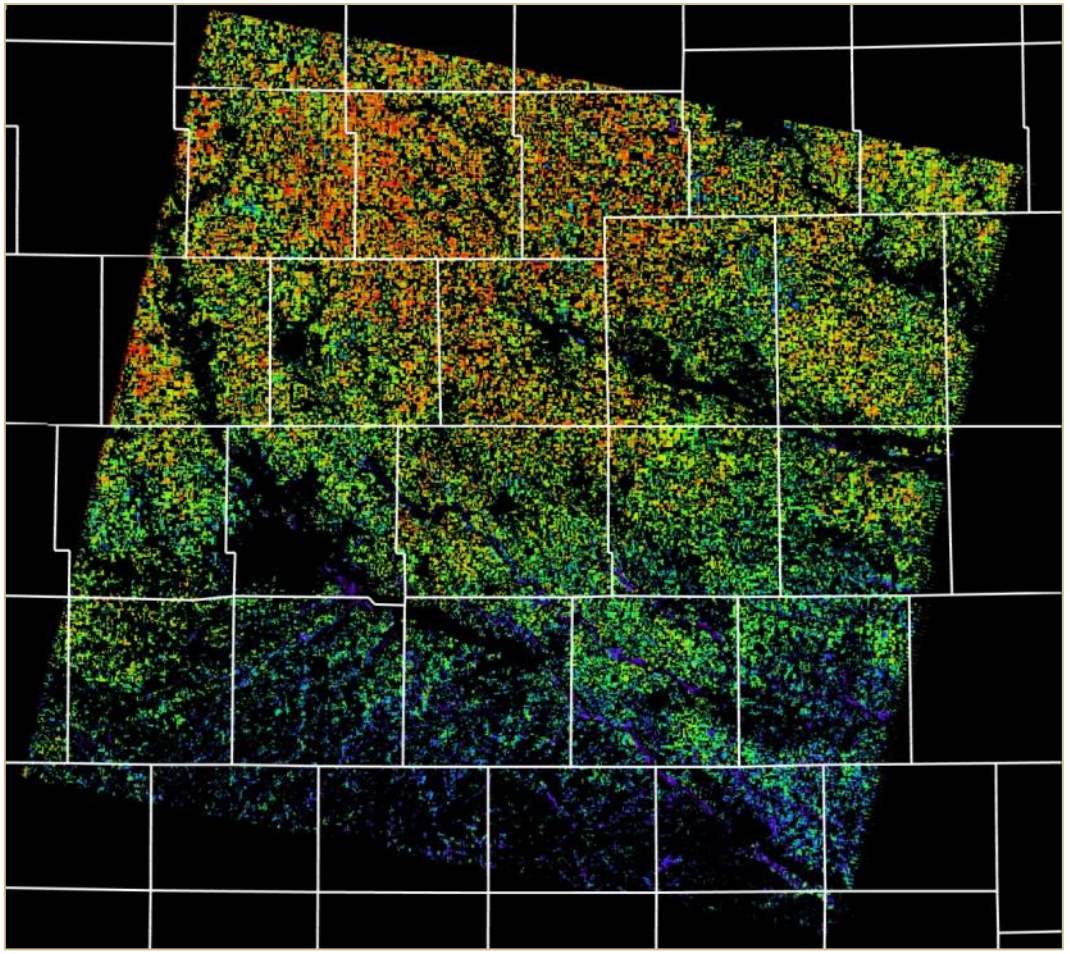




Estimated Yields at Field Scale
(corn, central Iowa, 2010)

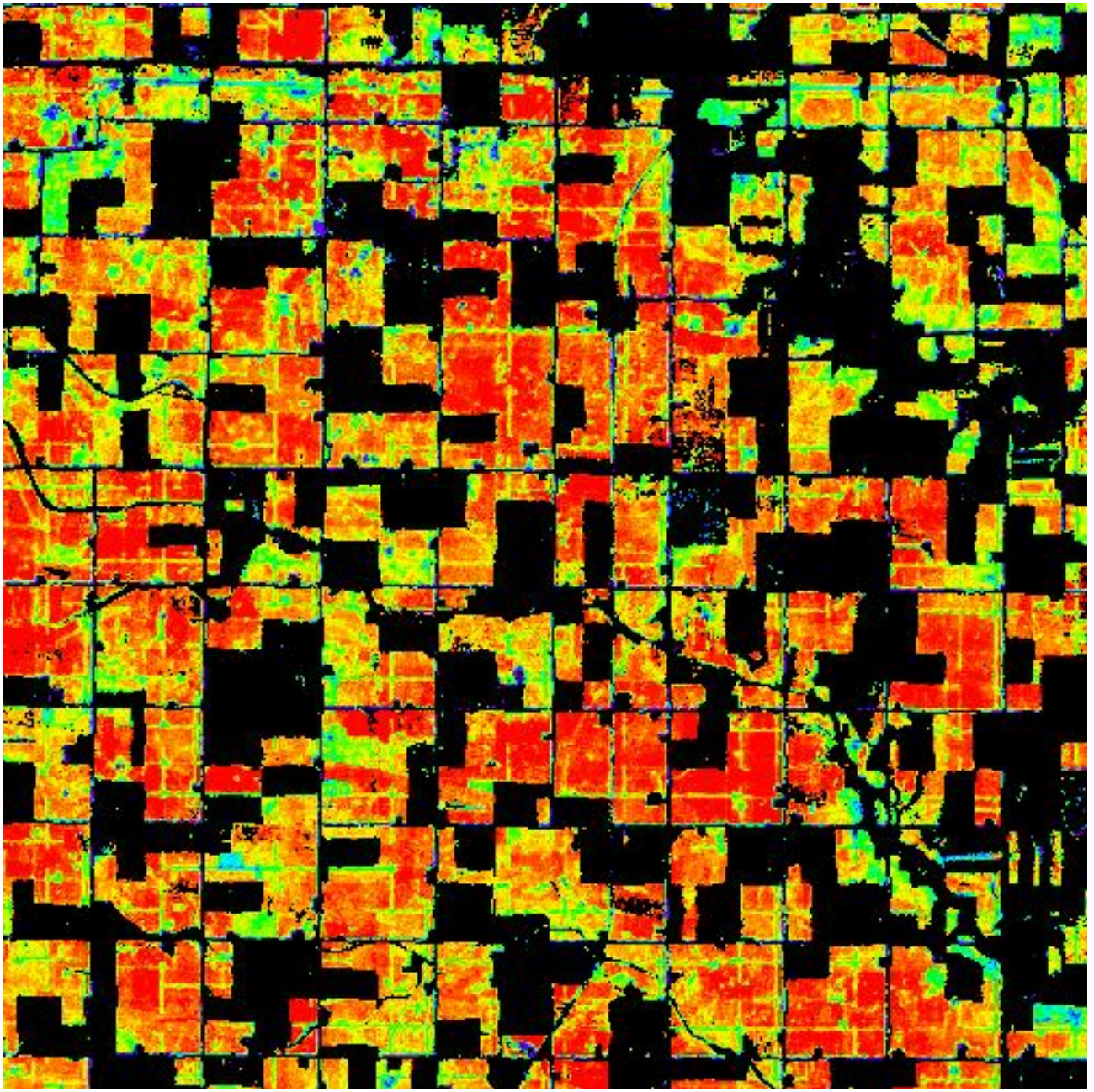






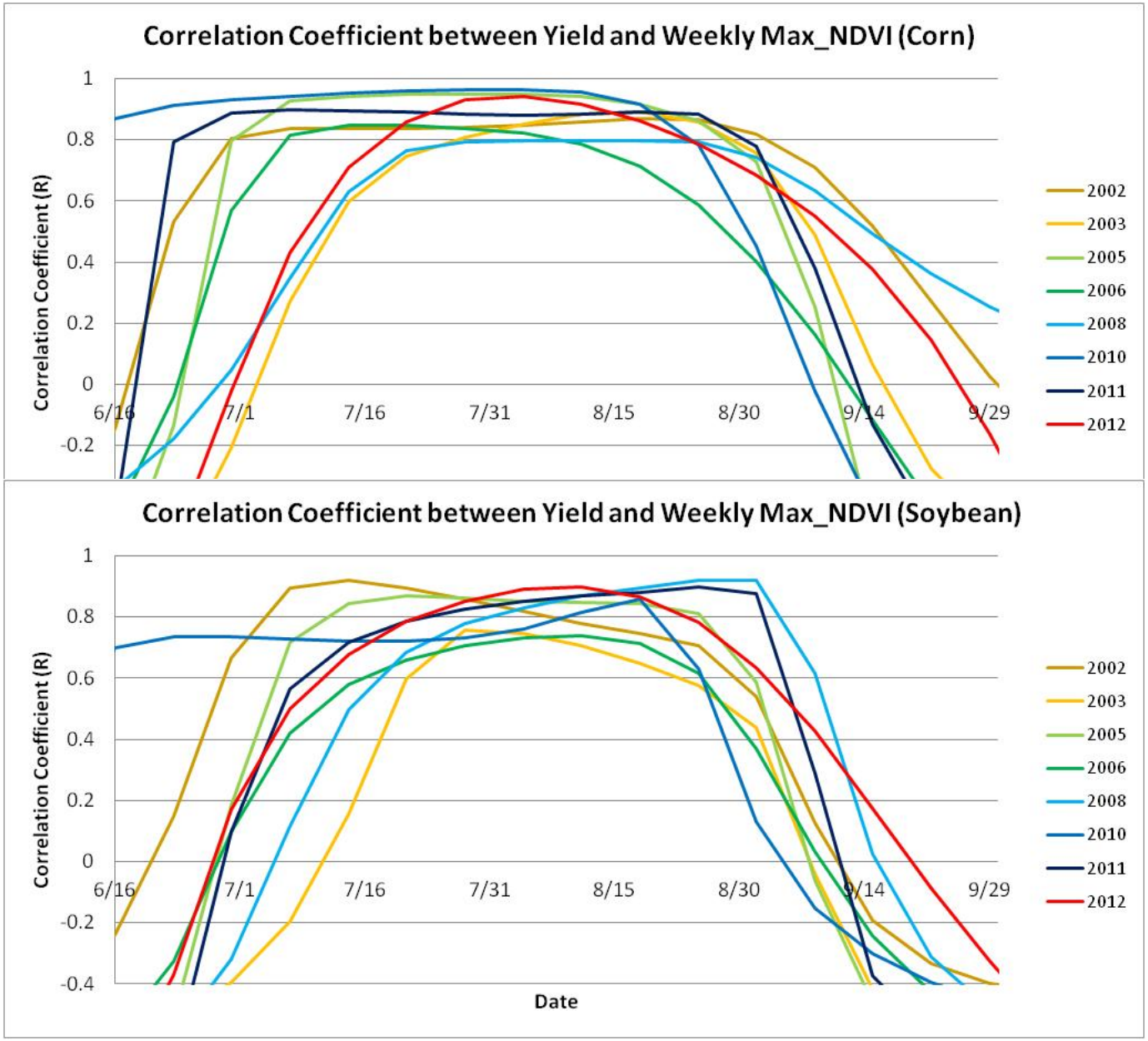
60 100 140 180 220 (Bu/Acre)

2010 Corn Yields (Bu/Acre) at South Fork



Crop Condition and Water Use Monitoring

Acquisition Dates are Critical for Yield Modeling



Case 2: Gallo Vineyards, Lodi CA

(Grape Remote sensing Atmospheric Profiling & Evapotranspiration eXperiment)

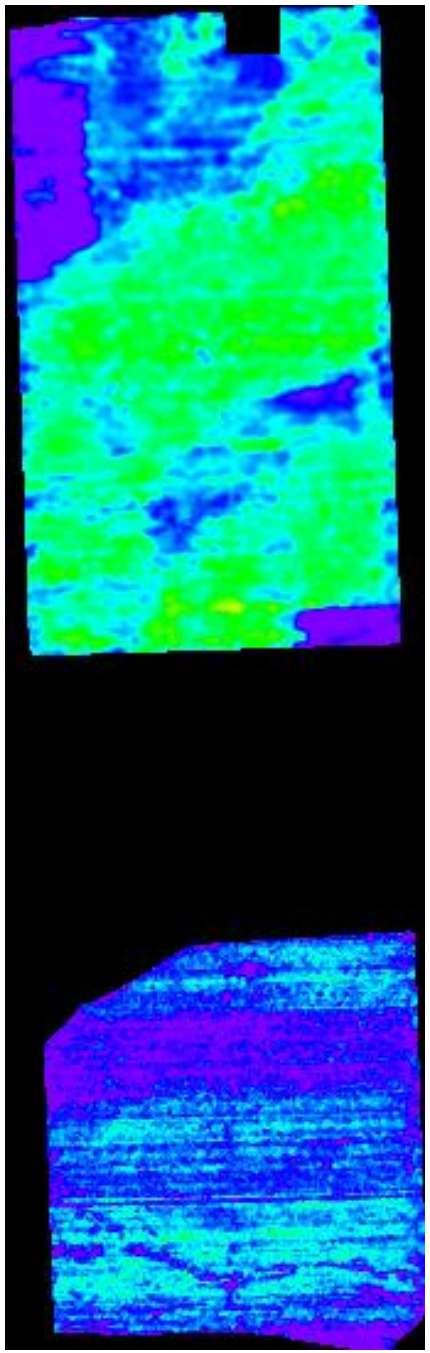
The two vineyards were heavily instrumented to measure meteorological, vegetation, and soil conditions including:

- meteorological quantities, *e.g.* wind speed, air temperature, and precipitation.
- surface energy balance.
- wind and friction velocity profiles.
- surface/canopy temperature.
- vine water use via sap flow sensors.
- soil temperature/moisture at multiple depths.
- leaf area index
- grape yield

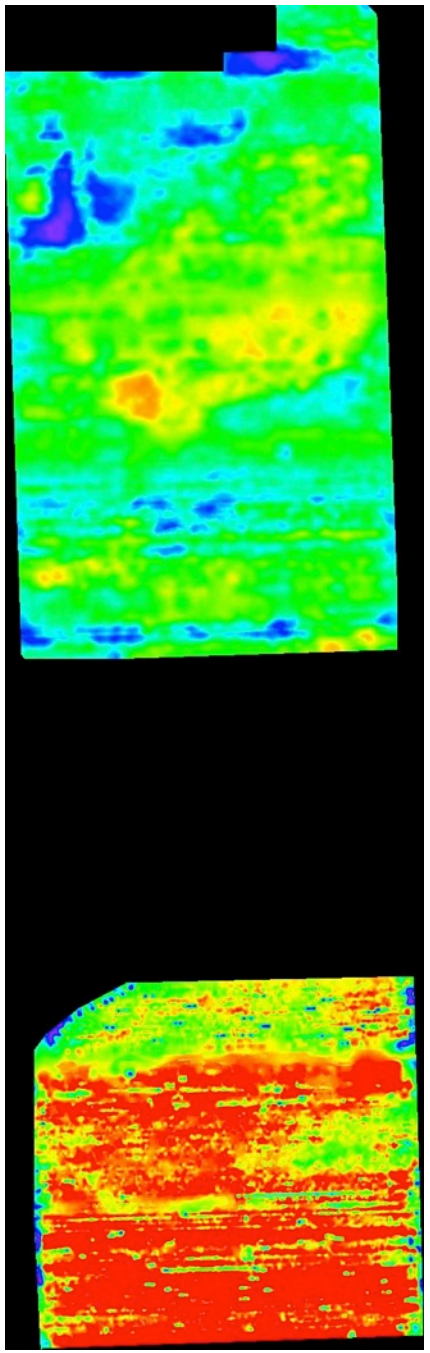
Field measurements and remote sensing data were collected from 2013 to 2016

Yield Monitoring

(tons/acre)

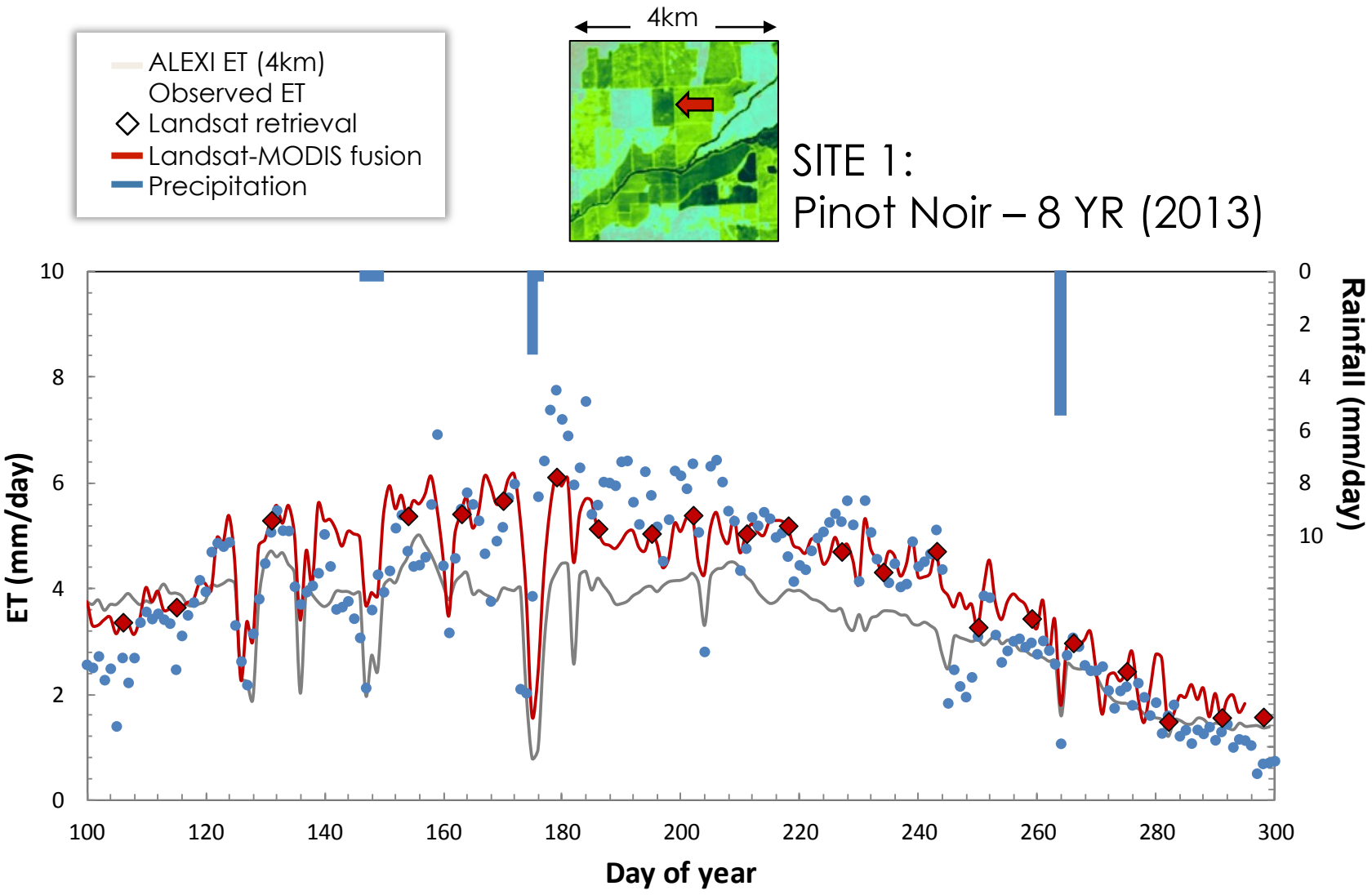


2013 (3m)



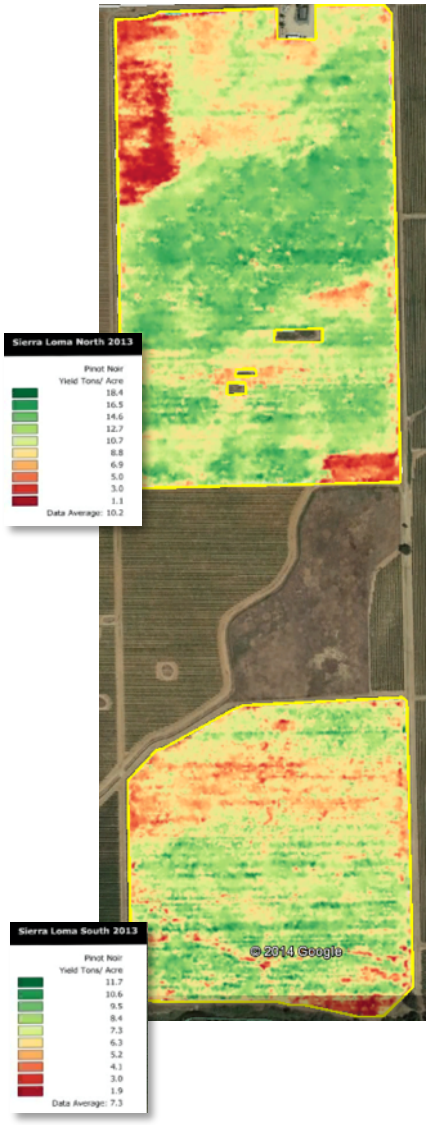
2014 (1m)

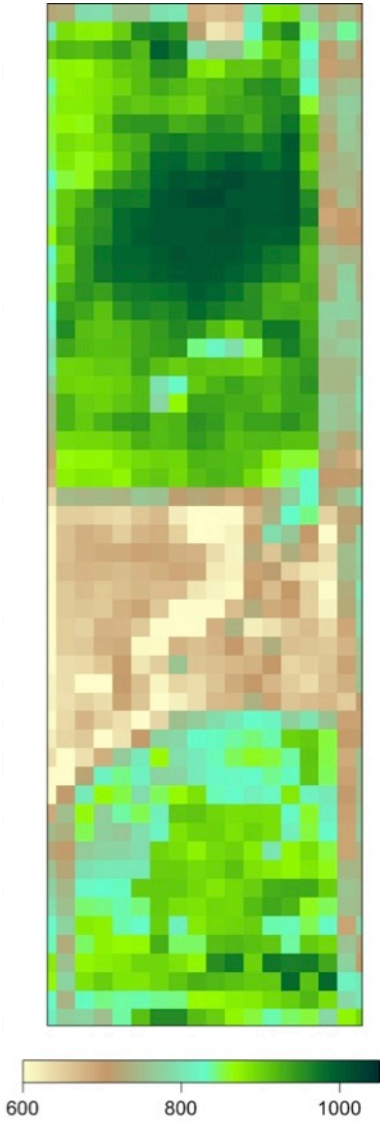
Crop Condition and Water Use Monitoring



Crop Condition and Water Use Monitoring

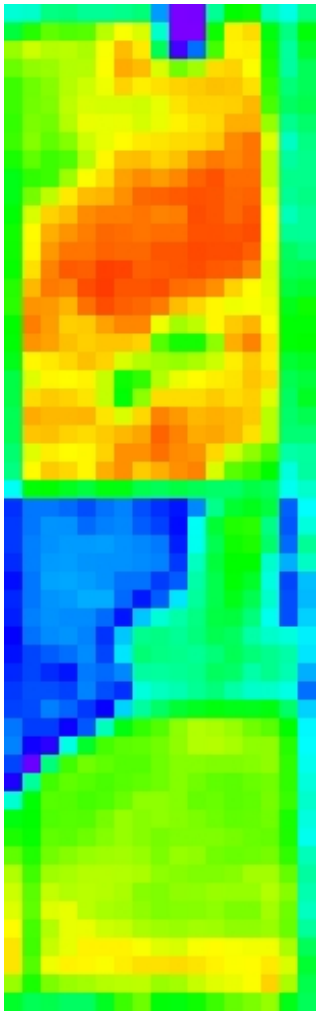
2013 Yield



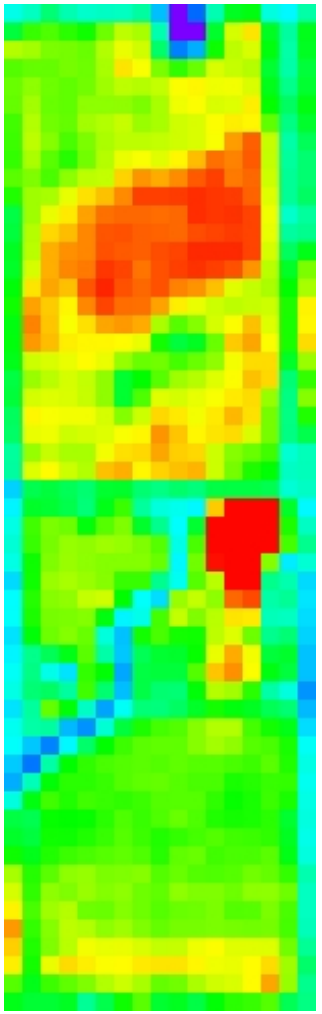


Cumulative ET

Landsat (30m)

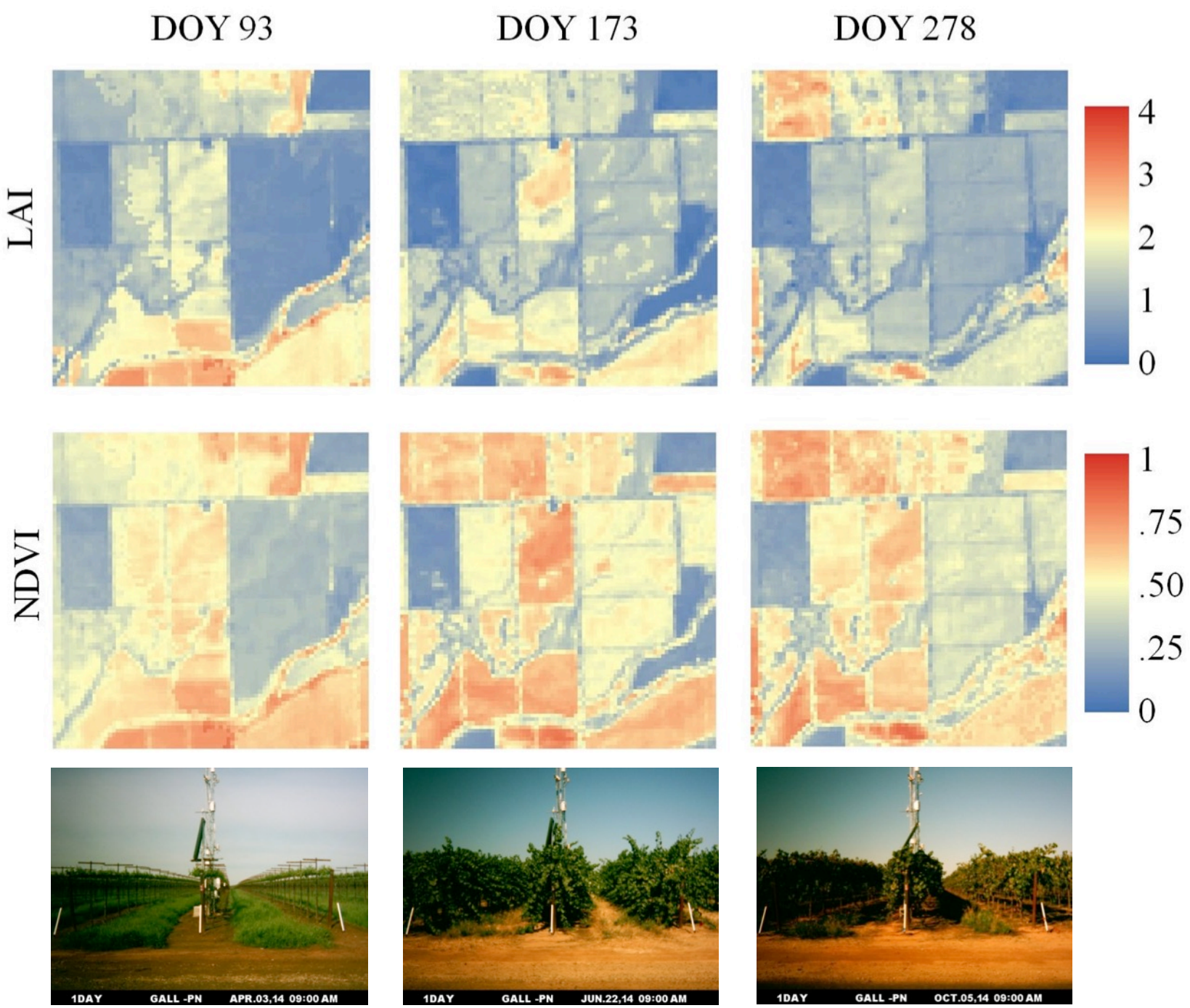


Cumulative LAI



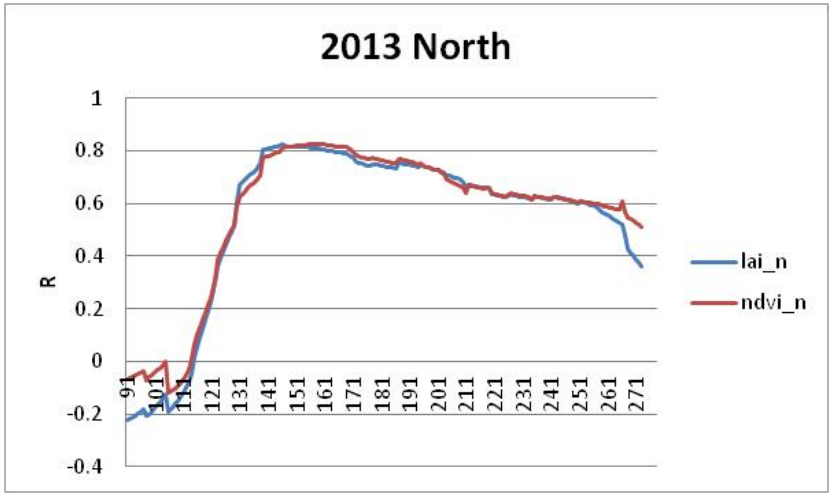
Max LAI

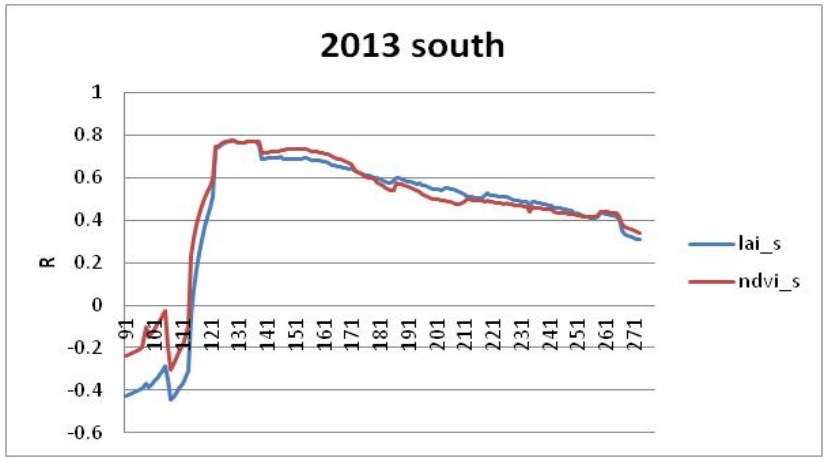
Crop Condition and Water Use Monitoring

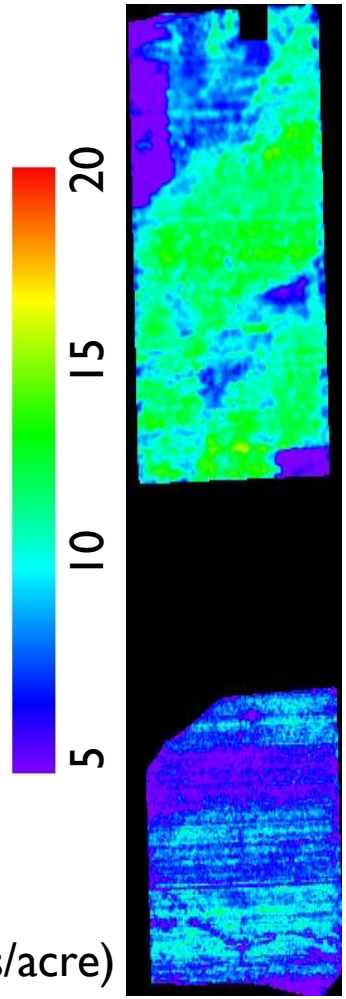


Crop Condition and Water Use Monitoring

Grape Yield Estimation

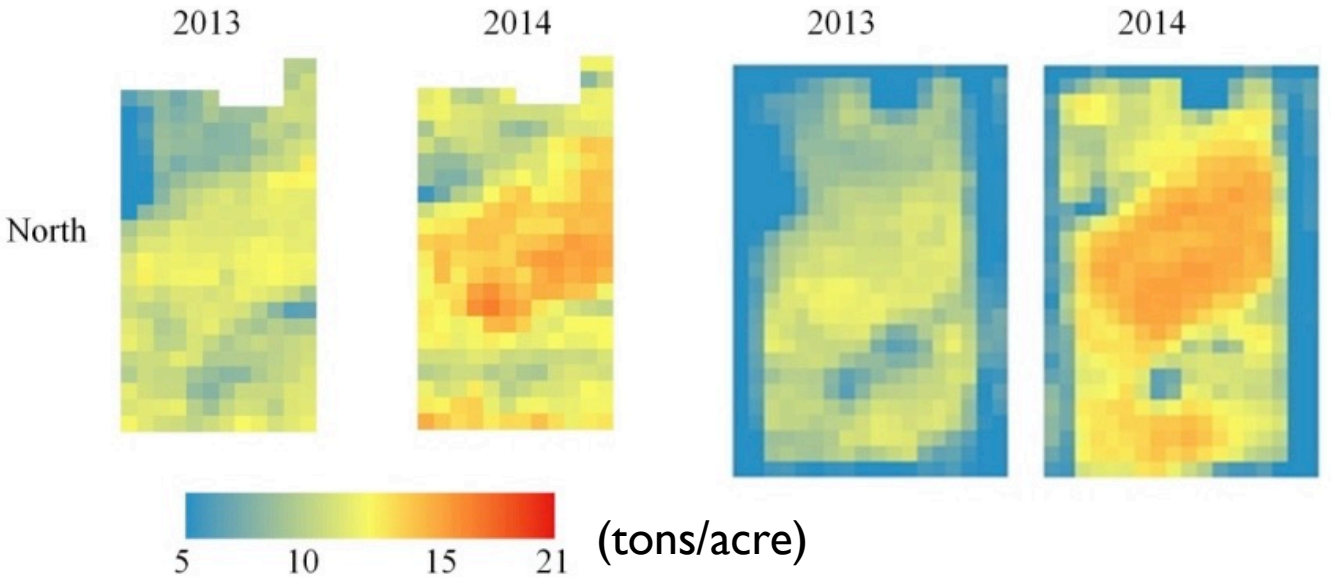






(tons/acre)

Estimate Grape Yield at Gallo Vineyards (Lodi ,CA) using Landsat and MODIS Data Products



- Grape yield depends on vine condition and management (e.g. pruning)
- Yield is harder to estimate but spatial variability are correlated to remote sensing observations
- Possible to predict yield with the help of limited field measurements

Summary

Integrated System

- STARFM data fusion
- DMS TIR image sharpener
- ALEXI/DisALEXI ET modeling
- LAI, Phenology …

Validation and Applications

- Crop phenology
- Daily crop water use and stress
- Drought Impact and early warning
- Yield estimation using time-series NDVI and ET (30m)

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